

Claims

- [c1] A method for determining a subsurface formation property, comprising:
- determining a volume fraction of a layer in a multi-electrical-layer model for an anisotropic region of the formation, wherein the multi-electrical-layer model includes a relative-lower-resistivity layer and a relative-higher-resistivity layer and the determining is based on a resistivity measurement;
- determining a resistivity for the relative-lower-resistivity layer and a resistivity for the relative-higher-resistivity layer based on the volume fraction and bulk resistivity measurements of the anisotropic region, wherein the bulk resistivity measurements include a horizontal resistivity measurement or a vertical resistivity measurement; and
- determining the formation property based on the volume fraction, the resistivity of the relative-lower-resistivity layer, the resistivity of the relative-higher-resistivity layer, a porosity measurement of the anisotropic region, and the bulk resistivity measurements.
- [c2] The method of claim 1, wherein the formation property

is a total water saturation.

- [c3] The method of claim 2, wherein the water saturation is determined according to:

$$S_{wt} = 1 - \frac{\phi_T - [(1 - VF) \sqrt{\frac{R_w}{R_{hr}}} + VF \sqrt{\frac{R_w}{R_s}}]}{\phi_T}$$

wherein S_{wt} is the total water saturation, ϕ_T is the total porosity of the anisotropic region, VF is the volume fraction of the relative-lower-resistivity layer, R_{hr} is the resistivity of the relative-higher-resistivity layer, R_{lr} is the resistivity of the relative-lower-resistivity layer, and R_w is a resistivity of formation water.

- [c4] The method of claim 1, wherein the formation property is a bulk hydrocarbon volume.

- [c5] The method of claim 4, wherein the bulk volume of hydrocarbon is determined according to:

$$BVH = \phi_T - [(1 - VF) \sqrt{\frac{R_w}{R_{hr}}} + VF \sqrt{\frac{R_w}{R_s}}]$$

wherein BVH is the bulk hydrocarbon volume, ϕ_T is the total porosity of the anisotropic region, VF is the volume fraction of the relative-lower-resistivity layers, R_{hr} is the resistivity of the relative-higher-resistivity layer, R_{lr} is

the resistivity of the relative-lower-resistivity layer, and R_w is a resistivity of formation water.

- [c6] The method of claim 1, wherein the volume fraction is of the relative-lower-resistivity layer.
- [c7] The method of claim 1, wherein the resistivity measurement is a high-resolution measurement.
- [c8] The method of claim 7, wherein the determination of a volume fraction includes identifying bed boundaries based on the high-resolution resistivity measurement.
- [c9] The method of claim 8, wherein identifying the bed boundaries includes finding inflection points on a derivative curve of the high-resolution resistivity measurement as a function of a borehole axial depth.
- [c10] The method of claim 1, wherein the volume fraction is determined by summing thicknesses of thin layers having similar electrical properties.
- [c11] The method of claim 1, wherein determination of the formation property is further based on a dual-water model or NMR data.
- [c12] The method of claim 1, wherein the volume fraction or the formation property is determined within a depth or time index interval.

- [c13] A system for determining a subsurface formation property, comprising:
- a computer system adapted to process a program including instructions for: determining a volume fraction of a layer in a multi-electrical-layer model for an anisotropic region of the formation, wherein the multi-electrical-layer model comprises a relative-lower-resistivity layer and a relative-higher-resistivity layer and the determining is based on a resistivity measurement;
- determining a resistivity for the relative-lower-resistivity layer and a resistivity for the relative-higher-resistivity layer based on the volume fraction and bulk resistivity measurements of the anisotropic region, wherein the bulk resistivity measurements include a horizontal resistivity measurement or a vertical resistivity measurement; and
- determining the formation property based on the volume fraction, the resistivity of the relative-lower-resistivity layer, the resistivity of the relative-higher-resistivity layer, a porosity measurement of the anisotropic region, and the bulk resistivity measurements.
- [c14] The system of claim 13, wherein the formation property is a total water saturation.

- [c15] The system of claim 14, wherein the water saturation is determined according to:

$$S_{\text{wt}} = 1 - \frac{\phi_r - [(1 - VF) \sqrt{\frac{R_w}{R_{\text{hr}}}} + VF \sqrt{\frac{R_w}{R_s}}]}{\phi_r}$$

wherein S_{wt} is the total water saturation,
 ϕ_r

is the total porosity of the anisotropic region, VF is the volume fraction of the relative-lower-resistivity layer, R_{hr} is the resistivity of the relative-higher-resistivity layer, R_{lr} is the resistivity of the relative-lower-resistivity layer, and R_w is a resistivity of formation water.

- [c16] The system of claim 13, wherein the formation property is a bulk hydrocarbon volume.

- [c17] The system of claim 16, wherein the bulk volume of hydrocarbon is determined according to:

$$BVH = \phi_r - [(1 - VF) \sqrt{\frac{R_w}{R_{\text{hr}}}} + VF \sqrt{\frac{R_w}{R_s}}]$$

wherein BVH is the bulk hydrocarbon volume,
 ϕ_r

is the total porosity of the anisotropic region, VF is the volume fraction of the relative-lower-resistivity layer, R_{hr}

is the resistivity of the relative-higher-resistivity layer, R_{lr} is the resistivity of the relative-lower-resistivity layer, and R_w is a resistivity of formation water.

- [c18] The system of claim 13, wherein the volume fraction is of the relative-low-resistivity layer.
- [c19] The system of claim 13, wherein the resistivity measurement is a high-resolution measurement.
- [c20] The system of claim 19, wherein determination of a volume fraction includes identifying bed boundaries based on the high-resolution resistivity measurement.
- [c21] The system of claim 20, wherein identifying the bed boundaries includes finding inflection points on a derivative curve of the high-resolution resistivity measurement as a function of a borehole axial depth.
- [c22] The system of claim 13, wherein the volume fraction is determined by summing thicknesses of thin layers having similar electrical properties.
- [c23] The system of claim 13, wherein determination of the formation property is based on a dual-water model or NMR data.
- [c24] The system of claim 13, wherein the volume fraction or the formation property is determined within a depth or

time index.